6.2 Soil Sampling

This recommended protocol outlines procedures, equipment and other considerations specific to the collection of representative surface and subsurface soil samples. When followed, these guidelines serve to maintain sample integrity by preserving physical form and chemical composition to as great an extent as possible. In addition to this section, the reader should refer to the following chapters in order to attain a more complete understanding of the requirements associated with soil sampling: Chapter 2, *Quality Assurance*; Chapter 5, *Sample Equipment*; Chapter 7, *Field Analytical Methods*; and Chapter 13, *Personnel Protection*. Finally, effective soil sampling can not be complete without reference to The Technical Requirements for Site Remediation (N.J.A.C. 7:26E, (http://www.state.nj.us/dep/srp/regs/techrule/).

6.2.1 Selection of Sampling Equipment

New Jersey's soil types range from the principally unconsolidated sandy soils of the southern coastal plain to the more heterogeneous soils in the north. Particular attention should be paid to the soil type being investigated in order to select the most appropriate sampling device. Generally, the northern region's rocky soil increases the difficulty obtaining a representative sample. Therefore, when sampling outside the coastal plain, extra consideration for the proper selection and advancement effort of the chosen sampling device must be factored into the planning of the sampling effort.

In certain site-specific circumstances, the parameters being investigated or the reagents being used for decontamination may influence the device's type and style of construction. Specifically, the sensitive chemical/physical nature displayed by the volatile organic fraction requires special consideration in sample equipment selection. Some sampling devices (e.g., bucket auger) may churn or otherwise alter or destroy certain physical attributes (e.g., pore space, ped formation, horizon delineation, color, etc.) and aerate the soil. This can cause an unwanted loss of volatiles from the sample. These devices can not be used for volatile organic sample collection. The recommended device (e.g., soil corer or split spoon) should produce a relatively undisturbed soil core, which will minimize the loss of VOCs and the destruction of soil characteristics (i.e., silt/clay). The chosen device should also be able to present the soil in such a fashion as to lend reasonable accessibility to field screening instruments (e.g., PID/FID) which in turn will assist in a reasonable interpretation of potential contamination across a measurable segment of the soil horizon. The optimum device will yield a sample, which has been minimally disturbed, where any biased sample may be easily identified and whose depth can be determined for future reference. For further clarification, advanced discussion with the regulatory authority is recommended before proceeding. Correct selection of sampling equipment will not only save time and expense, but will allow for collection of the most representative sample possible.

Typical soil sampling devices and accessories include but are not limited to the following:

- scoop or trowel*
- bucket/hand auger*
- soil coring device
- waste pile sampler
- split spoon sampler
- Shelby tube sampler
- mixing bowl or tray*
- spatula*

*Not acceptable for use when sampling VOCs

All of the above devices must be of stainless steel construction. In certain pre-approved circumstances, scoops or trowels constructed of rigid polyvinyl or polyethylenes are acceptable, but their reuse limited to a particular site and/or excessive wear. Another exception to this rule is the split spoon sampler, which is commonly constructed of carbon steel.

6.2.2 Equipment Preparation

After selection of the proper device, consideration must be given to equipment decontamination. When the decontamination procedure is properly performed (see Chapter 2), the potential for cross contamination can be significantly reduced. Care must be taken if a parameter of concern (i.e. acetone) is part of the decontamination process, or equipment damage by the reagents used during decontamination is a possibility (i.e. nitric acid rinse is detrimental to components constructed of bronze or carbon steel). When these site-specific questions arise, discussion with the regulatory authority may be prudent before a sampling plan is finalized.

All soil sampling devices used for chemical analysis must be decontaminated prior to use and in between sample locations. Once the equipment has been cleaned, it must be protected from incidental contact by wrapping in aluminum foil or placing in sealed plastic bags.

Additionally, any heavy equipment necessary for the advancement of any sampling device must be steam cleaned or high pressure/hot water washed prior to and between sample locations. This would include, but is not limited to, auger flights, drill rods, backhoe buckets and other respective accessories.

Depending on site conditions or sampling requirements, soil may have to be collected from beneath concrete pads, floors or asphalt paved areas. In these instances, the equipment used to expose the soil beneath must also be decontaminated if the equipment will directly contact the sample. Similar to the treatment of heavy equipment, decontamination of sampling equipment must be performed prior to each sample acquisition. Particular attention should be paid to the lubricating water associated with concrete coring equipment. If a potable water source is not available and the potential integrity of the sample is in jeopardy, analysis of the lubricating water used may be necessary.

It can not be overstated that costly and lengthy cleanup or permit decisions are based on the outcome of soil samples collected in relatively short order. Therefore, initial attention to equipment selection and its preparation can offer a significant reduction in oversight expense while providing the most professional results.

6.2.3 Soil Logs

Pursuant to N.J.A.C. 7:26E-3.6(a)2, a profile of subsurface conditions is required for investigations concerning soil contamination. Soil logs must be prepared to document soil types, field instrument measurements, depth to groundwater, soil mottling, presence of odors, vapors, soil discoloration, or the presence of free and/or residual product. Information obtained by performing the Standard Penetration Test (SPT, ASTM Method 1586-84) must also be included on the soil boring logs. Similar information must also be recorded when installing monitor wells, pursuant to N.J.A.C. 7:26E-4.4(g)4.

Important! Soil logs must be completed after sample collection for laboratory analysis to minimize losses due to volatilization and biodegradation as well as cross contamination due to excessive handling of the soil.

Soil logs should include a description of texture, moisture content, color, stratification, fabric and structure. Texture descriptions include the relative angularity, roundness and sorting of the particles as well as their grain size. Description of moisture content include terms such as dry, moist, wet, or saturated. Descriptions of soil fabric should include whether the particles are flat or bulky and whether the particles are stratified, laminated, varved etc. Soil color descriptions should reference Munsell color charts. Variations in color, e.g., mottling, can provide information on the extent of water-table fluctuations and geochemical conditions (aerobic vs. anaerobic) or formational changes. Soils with bright and uniform colors generally are well drained. Soils with gray or dull colors may be poorly drained. Color changes may also indicate the presence of contaminants. For example, soils and clay may become darker in a reducing environment ("gleying") caused by the presence of petroleum hydrocarbons. The size, type and condition of rock fragments should also be included (e.g., shale, sandstone, decomposed, and friable, etc.).

Soil texture must be classified according to one of the standard systems discussed below. Since there is some variability between the different soil classification systems, all logs should specify which soil classification system is being used or provide the size ranges on the log. For consistency, it is also important to compare the soil samples in the field with a reference card for the classification system being used. These are commercially available from various sources. The following is a discussion of some of the soil classification systems commonly used to characterize the texture of soils and sediments. Although the terms used in the classification systems (e.g., sand, silt, and clay) have mineralogical connotations, the terms used here refer strictly to soil and sediment textures. An example of a boring log is provided on page 23 to assist field personnel in recording observed soil data.

6.2.3.1 Wentworth Scale

The Wentworth scale was developed in 1922 and is based on the work of Udden. It is the generally accepted standard used by geologists and sedimentologists in North America (Pettijohn, 1975). It is a logarithmic scale in that each grade limit is twice as large as the next smaller grade limit (Folk, 1974, page 25). It is used to describe the texture of sedimentary rocks (e.g., sandstone) as well as unconsolidated sediments. The US Geological Survey uses this classification but has taken the gravel size range and subdivided it into groups as shown in Table 6.1 below.

Table 6.1 Wentworth Scale as Modified from Driscoll, 1986, and Folk, 1975.			
Wentworth Size Class	**Millimeters**	**Inches**	**Standard Sieve #**
Boulder	256 +	10.08 +	
Cobble	64 - 256	2.52 - 10.08	
Pebble	4 - 64	0.16 - 2.52	
Very coarse gravel	32 - 64	1.26 - 2.52	
Coarse gravel	16 - 32	0.63 - 1.26	
Medium gravel	8 - 16	0.31 - 0.63	
Fine gravel	4 - 8	0.16 - 0.31	No. 5 +
Granule (v.f. gravel)	2 - 4	0.08 - 0.16	No. 5 - No. 10
Very coarse sand	1 - 2	0.04 - 0.08	No. 10 - No. 18
Coarse sand	0.5 - 1	0.02 - 0.04	No. 18 - No. 35
Medium sand	0.25 - 0.5	0.01 - 0.02	No. 35 - No. 60
Fine sand	0.125 - 0.25	0.005 - 0.01	No. 60 - No. 120
Very fine sand	0.0625 - 0.125	0.002 - 0.005	No. 120 - No. 230
Silt	0.004 - 0.0625	0.0002 - 0.002	analyze by pipette or hydrometer
Coarse silt	0.031 - 0.0625		
Medium silt	0.0156 - 0.0625		
Fine silt	0.0078 - 0.0156		
Very fine silt	0.0039 - 0.0078		
Clay	below 0.0039	below 0.0002	

6.2.3.2 Unified Soil Classification System (USCS)

The USCS was developed for the US Army Corps of Engineers and Bureau of Reclamation for classifying soils for engineering purposes based on laboratory determination of particle size, liquid limit and plasticity index. It was first used to judge a soil's suitability as a subgrade for roads and airfields, but it is used today for most engineering applications of soil. It differentiates soils into three major divisions: coarse-grained, fine-grained and highly organic soils as shown in the table below. Fine-grained soils are classified as those that will pass through a No. 200 U.S. standard sieve (0.074 mm). Organic material is a common component of soil but it has no size range. Each type of soil is given a two-letter designation based primarily on its particle-size distribution (texture), Atterberg limits, and organic matter content. Tables 6.2 and 6.3 below describe the USCS.

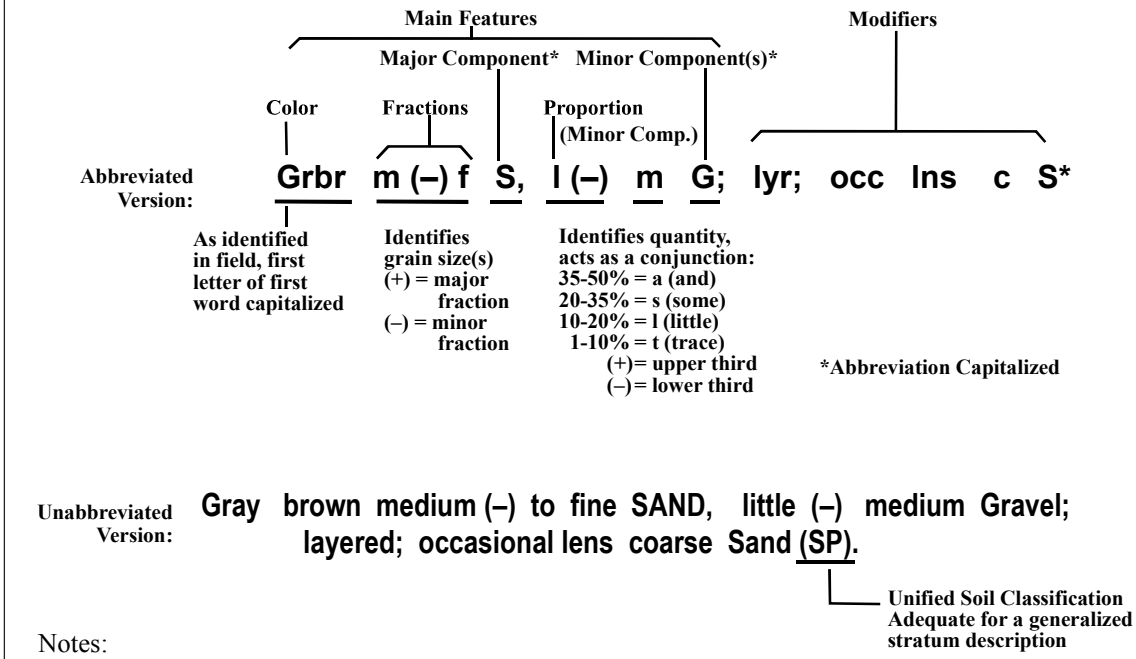
Table 6.2 Unified Soil Classification System; from American Society for Testing and Materials, 1985				
Major Divisions			**Group Sym.**	**Group Name**
Coarse Grained Soils–More Than 50% Retained On No.200 Sieve	Gravel–More Than 50% of Coarse Fraction Retained On No.4 Sieve	Clean Gravel	GW	Well-Graded Gravel, Fine to Coarse Gravel
			GP	Poorly-Graded Gravel
		Gravel With Fines	GM	Silty Gravel
			GC	Clayey Gravel
	Sand–More Than 50% of Coarse Fraction Passes No.4 Sieve	Clean Sand	SW	Well-Graded Sand, Fine to Coarse Sand
			SP	Poorly-Graded Sand
		Sand With Fines	SM	Silty Sand
			SC	Clayey Sand
Fine Grained Soils–More Than 50% Passes No. 200 Sieve	Silt And Clay Liquid Limit Less Than 50	Inorganic	ML	Silt
			CL	Clay
		Organic	OL	Organic Silt, Organic Clay
	Silt And Clay Liquid Limit 50 Or More	Inorganic	MH	Silt of High Plasticity, Elastic Silt
			CH	Clay of High Plasticity, Fat Clay
		Organic	OH	Organic Clay, Organic Silt
Highly Organic Soils			Pt	Peat

Table 6.3. Unified Soil Classification System (USCS)			
	Millimeters	**Inches**	**Sieve Size**
Boulders	> 300	> 11.8	-
Cobbles	75 - 300	2.9 - 11.8	-
Gravel:			
Coarse	19 - 75	0.75 - 2.9	-
Fine	4.8 - 19	0.19 - 0.75	3/4" - No. 4
Sand:			
Coarse	2.0 - 4.8	0.08 - 0.02	No. 4 - No. 10
Medium	0.43 - 2.0	0.02 - 0.08	No. 10 - No. 40
Fine	0.08 - 0.43	0.003 - 0.02	No. 40 - No. 200
Fines:			
Silts	< 0.08	< 0.003	< No. 200
Clays	< 0.08	< 0.003	< No. 200

6.2.3.3 Burmister System

The Burmister System uses similar textural size ranges as the Wentworth scale (see Tables 6.4 through 6.7). In addition, it adds a specific nomenclature to describe the soil's texture, color, plasticity, mineralogy, and even geologic origin, etc. as shown below.

Table 6.4 Burmister Soil Classification Naming System (source: Dunn Geoscience Corporation)



Notes:
Major Component (>50%): all letters are capitalized.
Minor Component: first letter is capitalized.

Table 6.5 Burmister Soil Classification System Coarse-Grained Soils, Gradation of Components

Coarse to fine	cf	All sizes
Coarse to medium	cm	Less than 10% fine
Medium to fine	mf	Less than 10% coarse
Coarse	c	Less than 10% medium and fine
Medium	m	Less than 10% coarse and fine
Fine	f	Less than 10% coarse and medium

Table 6.6 Burmister Soil Classification System Fine-Grained Soils, Plasticity of Components

Component	Symbol	Overall Plasticity	Plasticity Index
Silt	$	Non-plastic	0 to 1
Clayey Silt	Cy$	Slight	1 to 5
Silt & Clay	$ & C	Low	5 to 10
Clay & Silt	C & $	Medium	10 to 20
Silty Clay	$yC	High	20 to 40
Clay	C	Very High	over 40

Table 6.7 Burmister Soil Classification System, Components and Fractions, Modified from Burmister, 1950

	Millimeters	Sieve Size
Gravel (G):		
Coarse		1" - 3"
Medium		3/8" - 1"
Fine		No.10 - 3/8"
Sand (S):		
Coarse	0.590 - 2	No.30 - No.10
Medium	0.250 - 0.59	No.60 - No.30
Fine	0.074 - 0.25	No.200 - No.60
Silt ($):		
Coarse	0.074	0.02mm - No.200
Fine	< 0.020	< No. 200

6.2.3.4 U.S. Comprehensive Soil Classification System

The U.S.Department of Agriculture (USDA) developed the U.S. Comprehensive Soil Classification System. It was developed primarily in order to organize soils into established groups, identify their best uses and allow for estimates of their agricultural productivity (Dragun, 1988). It established ten soil orders (e.g., alfisols and ultisols, etc.) and uses soil profiles to characterize topsoil and subsoil horizons. Textural descriptions for the USDA system are shown in comparison to the other soil classification systems in Table 6.8 below.

Table 6.8 Textural Descriptions for USDA System

Granular Soils		Cohesive Soils		Grain Size (USCS)	
Blows/ft	Density	Blows/ft	Density	silt/clay	<0.08 mm
0-4	v. loose	>2	v. soft	f. sand	0.43 - 0.08 mm
4-10	loose	2-4	soft	m. sand	2.0 - 0.43 mm
10-30	m. dense	4-8	m. stiff	c. sand	4.8 - 2.0 mm
30-50	dense	8-15	stiff	f. gravel	19 - 4.8 mm
>50	v. dense	15-30	v. stiff	c. gravel	75 - 19 mm
		>30	hard	cobble	300 - 75 mm
				boulder	>300 mm

Proportions	
trace	0-10%
little	10-20%
some	20-35%
and	35-50%

6.2.3.5 Comparison of the Soil Classification Systems

As shown in Table 6.9, comparison of the different size classification systems shows that, although there are some similarities there are some differences between them. Notably, for most of the classification systems, the upper limit of coarse sand is 2.0 mm while the upper limit of coarse sand using the USCS is 4.8 mm, which is in the gravel range of most other systems. Sands and gravels have different hydraulic conductivity, which can affect the fate and transport of contaminants in the subsurface. For this reason, it is important to accurately describe the soil samples and reference the appropriate classification system being used to describe the soil samples in the soil boring log. When more than one mobilization of field equipment occurs or when different consulting firms are employed at a site, the same soil classification system should be used at a site for consistency. In addition, a qualified geologist or soil scientist should perform logging of soils and sediments. A recommended soil-boring log is provided following Table 6.9.

6.2.4 Field Log Books

In addition to soil logs, accurate field books are essential to the evaluation and interpretation of analytical results after sampling is complete. Information compiled in the field log book or soil logs for each sampling point should include:

- date/time/weather
- sampler/geologist/soil scientist name(s)
- sample identification (as specified in sampling plan)
- sketch showing the sampling location (including reference distances)
- depth to water and/or bedrock (refusal) when encountered
- soil profile using Wentworth, USCS, Burmister, or USDA classification, etc.
- sample recovery and interval submitted for analysis
- sampling equipment used
- field measurements of any direct reading instruments, their calibration, and settings
- general comments (e.g., odor, staining, etc.)

Table 6.9 Comparison of the Soil Classification Systems compiled from various sources

Wentworth	Burmister	USCS	USDA	mm	in	US Stan. Sieve Size
boulders		boulders	cobbles	4026		No. 5+
				2048		
				1024		
				512		
				256	10.08	
cobbles		cobbles		128	2.52	
				64		
v. coarse	coarse gravel	coarse gravel	medium gravel	32	1.26	
coarse pebble gravel	medium gravel	fine gravel	fine gravel	16	0.63	
medium				8	0.31	
fine	fine gravel			4	0.16	
gran. (vf) gravel		coarse sand		2	0.08	No. 5-10
v. coarse sand	coarse sand	medium sand	v. coarse sand	1	0.04	No. 10-18
coarse sand			coarse sand	0.5	0.02	No. 18-35
medium sand	medium sand	fine sand	medium sand	0.25	0.01	No. 5-60
fine sand	fine sand		fine sand	0.125	0.005	No. 60-20
v. fine sand			v. fine sand	0.031	0.002	No. 120-No. 230
	coarse silt	silts & clays	silt			
coarse silt	fine silt			0.0625		<No. 230
medium silt				0.0156		
fine silt				0.0078		
v. fine silt				0.0039	0.0002	
clay			clay	<0.0039	<0.0002	

Boring Log

Project Name: _____ **Project No:** _____ **Boring No:** _____

Location: _____ State Plane Coords.: X= Y= **Well No:** _____

Drilling Contractor: _____ Water Table Depth: _____ Date Started: _____

Geologist: _____ Drilling Equip.: _____ Date Comp.: _____

Sampling Method: _____ Size/Type of Bit: _____ Weather Cond.: _____

FID/PID Used: _____ Development Method: _____ Hammer Weight/Fall: _____

Soil Class System: _____ _____ Total Depth: _____

_____ Well Yield: _____ Ref. Elevation: _____

Screen Length/Type: _____ Riser Stickup: _____ Notes: _____

Sand Pack Amount/Type: _____ Riser Length/Type: _____ _____

Screen Slot Size: _____ Permit No.: _____ Sump Installed/Length: _____

Depth (ft.)	Sample No.	Blows per 6 in.	Penetration/ Recovery	FID/PID Reading (ppm)	Sample Description	Well Construction	Remarks

Site conditions (including equipment refusal) may warrant relocation or modification of the sampling plan during actual field activities. If this occurs, additional information should be noted in the field book noting the sampling plan modification and new sample location relative to the old as well as fixed objects such as a building or road. This will ensure accurate data interpretation for the modified sampling plan by non-field personnel.

6.2.5 Determination of Soil Sample Location

Determination of sample location is the first step in proper sample collection. In general, sampling should be conducted in potentially contaminated areas of concern, whether relating to former or current uses of the site to determine whether contaminants are present above applicable standards. Locations should be biased to suspected areas of greatest contamination based on professional judgment, site history, stressed vegetation, soil discoloration, odor, etc (N.J.A.C. 7:26E-3.4 to 3.6). Sample locations should also be chosen based on Area Specific Requirements pursuant to N.J.A.C. 7:26E-3.9 such as sampling in and around above and below ground storage tanks, impoundments, septic tanks, etc.

6.2.5.1 Surface Soil Selection

Surface soil samples should be collected using decontaminated or dedicated sampling equipment dependent on the chosen analytical parameter and sampling locations. All inconsequential surface debris (e.g., vegetation, rocks, etc.) should be removed from the surface before commencing sampling. Disposable gloves should be changed between each sample location. Care should be taken to minimize contact of disposable gloves with soil to be sent for laboratory analysis.

Initial characterization soil sampling with the exception of Area Specific Requirements and soil to be analyzed for VOCs, should be collected from the zero to 6 inches below grade. Additional sampling of soil below the 0 to 6.inch interval or those specified in the Area Specific Requirements may be necessary where the surface has been regraded or physical evidence indicates the possible presence of deeper contamination.

Soil samples shall be collected from discrete six-inch intervals. Deviations from this requirement due to poor sample recovery or logistical problems should be noted in the soil log and field logbook. Composite sampling is not allowed except in the case of waste characterization analysis for proper disposal. Surface soil collected for parameters other than VOC analysis should be homogenized in-situ or in a decontaminated stainless steel bowl or tray. Sampling should occur in progression from the least contaminated area to the most contaminated area, if this information is available.

Soil logs should be completed after sample collection to minimize losses due to volatilization and biodegradation, and cross contamination due to excessive handling of the soil.

Soil samples collected for VOC analysis must be handled in a manner that will minimize losses due to volatilization and biodegradation. See section 6.2.7., *VOC Sample Collection for Soils*, for appropriate sample collection procedures.

Soil samples collected for analytical parameters other than VOCs must be homogenized before being placed into the appropriate sample container. See section 6.2.8., *Non-VOC Sample Collection for Soils*, for appropriate sample collection procedures.

6.2.5.2 Subsurface Soil Selection

The advancement of any downhole large-diameter sampling device must follow ASTM #D1586-84 for disturbed (split spoon) samples, or, ASTM #D1586-83 for undisturbed (Shelby tube) samples. In addition, all borings must be performed in accordance with the procedures and regulatory requirements pursuant to the Subsurface and Percolating Water Act, N.J.S.A. 58:4A-4.1 et. seq. Soil boring permits are required for borings greater than 50 feet in depth. Borings greater than 25 feet deep must be sealed with approved sealing material pursuant to N.J.A.C.7:9D-3.4. Borings less than 25 feet deep may be sealed by backfilling with cuttings/ sand in pursuant to NJAC7:9D-3.4. However, NJDEP recommends that contaminated soils should not be returned to the borehole. If the contaminated soils are returned back to the borehole, the responsible party shall address the presence of this contamination in the remedial action workplan in pursuant to NJAC 7:26E-3.6.

Subsurface soil samples can be collected via a standard drill rig or direct push drilling by advancing a dedicated or decontaminated large-diameter sampling device (e.g., split spoon, Shelby tube or soil corer) in the borehole. A decontaminated split spoon retaining basket should be used to prevent loss of the soil back into the borehole while raising the split spoon sampling device to the surface. Upon retrieval to the surface, the large-diameter sampling device (e.g. split spoon, soil corer or Shelby tube) should be handled and transported in such as way to prevent lose while opening or during shipment preparation. The split spoon or soil corer sampling devices should be opened with caution to ensure that soil remains within one half of the split barrel or liner for later screening and sample collection. Soil that has fallen out of the large-diameter sampling device can not be used for laboratory analysis and should be discarded to prevent cross-contamination.

The top few inches of soil collected either via split spoon or soil core liner sampling device may contain material (often referred to as slough-pronounced sluff) that may have fallen back into the borehole. In addition “mud or water” used during rotary drilling may infiltrate into the surrounding formation. This infiltration may also be visible in the top few inches of the core or as coating on the core’s outer edges. This “slough or mud/water impacted soil” is not representative of in-situ conditions, should not be used for laboratory analysis and should be discarded to prevent cross contamination.

Upon opening, the split spoon or soil core liner should be opened and screened with a direct reading instrument (DRI) to determine the sample interval of interest. Soil samples shall be collected from discrete six-inch intervals. Deviations from this requirement due to poor sample recovery or logistical problems should be noted in the field logbook. Disposable gloves should be changed between each sample location. Care should be taken to minimize contact of disposable gloves with soil to be sent for laboratory analysis. Soil logs should be completed after sample collection to minimize losses due to volatilization and biodegradation, and cross contamination due to excessive handling of the soil.

Shelby tubes are typically used to collect undisturbed solid soil cores for laboratory analysis such as geotechnical parameters. Shelby tubes, once collected, should not be open by field personnel. Upon retrieval from the borehole, the Shelby tubes should be wiped clean and the ends sealed with melted wax to prevent leakage or drying of the soil core. Endcaps should be placed on both ends and taped prior to shipment to the laboratory.

Composite sampling is not allowed except in the case of waste characterization analysis for proper disposal.

Soil samples collected for VOC analysis must be handled in a manner that will minimize losses due to volatilization and biodegradation. See section 6.2.6., *VOC Sample Collection for Soils*, for appropriate sample collection procedures.

Soil samples collected for analytical parameters other than VOCs must be homogenized before being placed into the appropriate sample container. See section 6.2.8., *Non-VOC Sample Collection for Soils,* for appropriate sample collection procedures.

6.2.6 Field Screening Soil Samples

Each soil core should be screened with a properly calibrated direct reading instrument (DRI) equipped with a PID or FID detector or other suitable field-screening instrument capable of detecting the contaminants of concern pursuant to N.J.A.C. 7:26E-2.1(b).

To obtain the most representative monitor reading, use a decontaminated stainless steel spoon, knife or other appropriately constructed device and make a longitudinal score deep enough to expose a porous surface the length of the core. Or optionally, make very small divots at six-inch intervals to expose a porous surface. Simultaneously, place the probe of the DRI immediately above the opened area being careful not to touch the sample, and move the probe slowly above the lateral scoring and note any peaks. Record results of peaks in 6-inch intervals to determine sample location. Instrument readings will be biased low and not representative of in-situ conditions if the soil core is not scored or inner core not exposed for proper field screening. Other methods of field screening (e.g., bag headspace, jar headspace, warming, UV light, dye testing etc.) should be discussed with the appropriate regulatory authority for approval before sample collection.

The Technical Requirements for Site Remediation N.J.A.C. 7:26E-3.6(a)4.(ii), instruct one to select a six-inch increment of soil for volatile organic laboratory analysis based on field screening with a DRI. If a boring is continuously cored to 20 feet below grade where ground water is first encountered, then 4 to 5 individual 48" - 60" soil core segments will have to be opened and screened before determination as to which six-inch increment is to be selected for sampling and analysis. Special attention must be paid to labeling and storage of individual core samples when continuous soil samples are collected from a single boring. In many instances soil cores can be produced faster than they can be opened, logged, screened and sampled by a technician. In those instances when a backlog of cores are being generated, care must be made to protect the cores from direct sunlight, excessive ambient temperatures and rain. These conditions may have an adverse effect on highly sensitive volatile organics within the core or the instruments used for screening. Always keep the cores labeled so that the up/down orientation is not lost. Proceeded carefully, but quickly when field screening. If necessary, log soils for lithology information *after* sample collection. Always calibrate the DRI at the start of each day.

Another option is to select (using the DRI), and sample (using a small diameter coring device), a six-inch increment from every individual core segment, and only submit the sample required from that particular boring for analysis as directed in 7:26E-3.6(a)4(ii). This option can be more costly as several sample containers will have to be discarded at the end of the each boring. If chemical preservation is used (methanol), proper disposal could be an issue. Sampling every individual core first, prior to determining which increment to ship for laboratory analysis will also require additional labor. This particular option, to collect a representative six-inch incremental sample from every individual segment of a continuous core with its associated cost, makes the first option to carefully protect and manage the cores to control the loss of volatile organics even more critical.

6.2.7 VOCs Sample Collection for Soils

VOCs can be mobile as either gas or liquid phases in a non-aqueous environment. Because unique physical and chemical characteristics associated with each of these phases contribute to a contaminant's behavior in a non-aqueous environment, accurate identification and quantification of VOCs in this matrix becomes essential.

Precise characterization of VOCs in soil, and other non-aqueous matrices (e.g., sediment), is critical since decisions for remediation are based on analytical measurement. Unfortunately, it has been the acts of collection and storage that subject a sample to numerous variables that can alter VOC concentration. These variables may enhance volatilization and biodegradation of VOCs in the sample.

To improve sample collection procedures and storage requirements of soils and other non-aqueous matrices for VOC analysis, samples must be handled in a manner that will minimize losses due to volatilization and biodegradation. Many environmental professionals have conducted and are continuing research to determine how to best maintain the integrity of samples collected for VOC analysis. This ongoing research has resulted in analytical and sampling procedure updates. Current sample preparation and analytical methods can be found in the USEPA Office of Solid Waste and Emergency Response's (OSWER), *Test Methods for Evaluating Solid Waste Physical/Chemical (SW-846)* and, *USEPA Contract Lab Program (CLP) Statement of Work (SOW) for Organic Analysis, Multi-Media, Multi-Concentration*.

6.2.7.1 VOC Soil Sample Depth Selection

Soil sample collection for VOC analysis is a two-step process consisting of the collection of the larger soil core and sub-sampling this larger soil core for submittal to an analytical laboratory. The collection of all soil and non-aqueous samples for VOC analysis must be as follows:

The collection of samples for VOC analysis must be performed with a decontaminated or dedicated large-diameter coring device such as a split spoon or soil corer, which does **not** break up the structure of the matrix. These sampling devices typically have a diameter range of 1.5 to 4 inches. Use of a soil collection device that causes mixing, such as a hand auger, cannot be used for VOC sample collection since the tool will break up the soil structure and aerate the soil causing significant VOC loss.

When sampling for VOC analysis, the device must be retrieved from the borehole as soon as possible. Each large-diameter soil core should be screened with a properly calibrated DRI equipped with a PID or FID detector or other suitable field-screening instrument capable of detecting the contaminants of concern pursuant to N.J.A.C. 7:26E-2.1(b). Field screening data should be recorded on the soil boring log or other field documentation for eventual reporting in the investigation report.

Important! **Soil samples for VOC analysis must be collected immediately (within minutes) to reduce loss of VOCs to volatilization and biodegradation.**

Using the field-screening data, select samples for VOC analysis using the following criteria:

If field-screening measurements are detected above background:

- Extend the boring from ground surface until either background readings are achieved, ground water is encountered or bedrock is encountered; and

- Collect a soil sample from the six (6) inch interval registering the highest value on the DRI, at a minimum, using the appropriate sample collection method and device as specified in N.J.A.C. 7:26E-2.1(a)4 and
- Collect any additional samples as necessary based on DRI readings or laboratory data to delineate VOC contamination pursuant to the requirements specified in N.J.A.C. 7:26E-4.1 and 4.3.

If all intervals register the same measurement from the DRI or if all measurements do not exceed background:

- Extend the boring to ground water, bedrock, or 10 feet, whichever is encountered first, and;
- Collect an undisturbed sample from the six-inch interval at the bottom of the soil boring, at a minimum, using the appropriate sampling sample collection method and device as specified in N.J.A.C. 7:26E-2.1(a)4.
- Collect additional samples as necessary based on DRI readings or laboratory data to delineate VOC contamination pursuant to the requirements specified in N.J.A.C. 7:26E-4.1 and 4.3.

Contaminants that cannot be detected with field screening instrumentation must be sampled from locations or depths that are most likely to be contaminated based on the location and nature of the discharge or type of matrix to which the contaminant was discharged (N.J.A.C. 7:26E-3.4(a)). Include this information in the appropriate field documentation for eventual reporting in the investigation report.

6.2.7.2 VOC Soil Sample Collection Devices - Small Diameter Core Samplers

Important! **Soil samples for VOC analysis must be collected immediately (within minutes) to reduce loss of VOCs to volatilization and biodegradation.**

Soil to be collected for laboratory analysis **can not** be stored for extended periods in the large-diameter sampling device or a capped liner (brass, acetate, lexan, polycarbonate etc.) for later sample collection. In addition the soil **can not** be transferred to an intermediate container such as another empty sample bottle, zip lock bag, aluminum foil, etc, for later sample collection. Research has shown leaving samples in core tubes, splitspoons, covered liners or intermediate containers will lead to VOC losses and thus yield poor quality data. See Section 6.2.6., *Field Screening Soil Samples*, for more information.

Sub-sampling of the large-diameter sampling device for VOCs must be performed with the use of a dedicated or decontaminated small-diameter core sampler. The small-diameter core sampler must be capable of collecting the required amount of sample from the large-diameter sampling device (e.g., split spoon or soil corer) or from freshly exposed soils. The small-diameter core sampler must be capable of delivering the sample quickly and directly into the sample container without disturbing the native soil structure.

It is important that the small-diameter core sampler provide the required mass of sample material. As such, a **test sample** (of similar matrix to be sampled) should be collected and weighed to determine the amount of soil needed to obtain the required mass of sample material for each type of small-diameter core sampler and analytical method. Using a small electronic portable scale with an accuracy of 0.1grams, weigh the empty small-diameter core sampler (e.g., disposal syringe) to the nearest 0.1grams. The scale must be calibrated before use and intermittently checked during the day to ensure accurate weight measurement. Calibration information must be recorded in the field logbook. A translucent cover can be placed over the scale during the weighing process to negate variations caused by wind. Push the small-diameter core sampler

test sample into the matrix to collect the required mass of material (3cm^3 should yield approximately 5-grams of sample [wet weight]). Wipe clean any soil adhering to the outside of the small-diameter core sampler before weighing. If the weight is above the required amount, excessive soil can be removed by extruding a small portion of the core and cutting it away with a decontaminated trowel or spatula. If the weight is below the weight limit, obtain additional soil by reinserting the small-diameter core sampler into the soil core. Reweigh after each addition or removal of sample from the small-diameter core sampler until the target weight is attained. Note the sample volume and amount in the small-diameter core sampler. **Discard the test sample.** Use this volume when collecting soil of similar matrix. Additional test samples should be weighed whenever a change in the matrix is observed.

All small-diameter core samplers used in the collection of samples for VOCs must be constructed of non-reactive materials that will not sorb, leach or alter the concentration of VOCs in the sample. Examples of these materials are stainless steel, glass and brass. Other materials, such as Viton, PTFE and some ridged plastics, which have demonstrated limited absorptive or diffusive passage of VOCs, can be used as long as the contact time between the sample and the sampler is minimized, or, the materials are used for an airtight seal of the sampler.

Acceptable small-diameter core samplers include a modified 10-ml disposable plastic syringe, a Purge and Trap Soil Samplerä, En Core® sampler, Easy Draw Syringe® or other small-diameter tube/plunger sampler. The small-diameter core sampler must be able to deliver a minimum of 5-gram sample (≈3cm^3 of sample assuming a density of 1.7g/cm^3) into a 40-ml VOA vial. While most small-diameter core samplers can only be used for sampling and placement into the appropriate sample containers, only the En Core® sampler can be used for sampling, storage and transportation of the sample to the lab. Small-diameter core samplers should be selected based upon the properties of the matrix, the type of preservation method (field vs. lab) and personal preferences.

6.2.7.2.1 Disposable Syringe

A disposable syringe is an easy and inexpensive tool for sample collection and transfer to appropriate sample containers. It can be prepared by cutting off the injection tip, removing the rubber plunger tip, and removing the retaining post on the plunger. If the plunger maintains a tight seal with the barrel of the syringe, the plunger must be flush with the opening of the barrel for sampling. This position will prevent air from being forced through or around the sample plug during sample collection and extruding into the sample container. If a modified disposable syringe is used, syringes with less than 5 cm^3 total volume cannot be used. Research has demonstrated that high surface-area to total volume ratios in soil cores create significant volatilization loss within seconds of exposure to such devices.

The disposable syringe is a one-time use device and cannot be decontaminated.

The disposable syringe can not be used for storage or shipment to the laboratory. The soil sample must be transferred into appropriate sample containers immediately upon sample collection for proper preservation.

6.2.7.2.2 Easy-Draw Syringe and Power-Stop Handle

The Easy-Draw Syringe® and Power-Stop Handle® is a 5-gram volumetric coring system for sample collection and transfer into appropriate sample containers. The

device consists of two parts, the sampling syringe and handle. The polypropylene syringe is used to collect and transfer the sample. The handle allows for easier sampling and controls the volume of soil collected. The handle has three positions to control the volume of soil collected based on the density of the matrix and can be set to collect 5, 10 or 13-gram samples.

Once the sample is collected, remove any excess material that extends beyond the end of the syringe and cap. Remove the syringe from the handle and extrude the sample into the appropriate sample container.

The Easy-Draw Syringe® and Power Stop Handle Purge and Trap Sampler® can not be used for storage or shipment to the laboratory. The soil sample must be transferred into appropriate sample containers immediately upon sample collection for proper preservation.

6.2.7.2.3 Purge and Trap Soil Sampler®

The Purge and Trap Soil Sampler®is a 5-gram volumetric coring system for sample collection and transfer into appropriate sample containers. The device consists of two parts, the coring tube and the handle. The coring tube is removable from the handle, so numerous core tubes can be used with one handle. The sampler is also capable of sampling harder materials than other sampling systems. If sample weights other than 5 grams are required, the device can be adjusted so sample sizes of 1 to10 grams can be collected. The supplied plunger is used to extract the sample into the sample container.

The Purge and Trap Soil Sampler® is constructed of stainless steel, which allows the sampler to be decontaminated for reuse.

The Purge and Trap Soil Sampler® can not be used for storage or shipment to the laboratory. The soil sample must be transferred into appropriate sample containers immediately upon sample collection for proper preservation.

6.2.7.2.4 En Core® Sampler

The En Core® sampler is a one-time-use volumetric sampling and storage device. The En Core® sampler is made of an inert composite polymer designed to collect, seal and store a 5-gram sample, with no headspace, prior to preservation or analysis. The En Core® sampler is designed to extrude the sample directly from the coring body into the sample container without disturbing the matrix structure. The sampler has three components: the coring body, the plunger and the cap. A specially designed "T" handle, available from the manufacturer, is used to push the En Core® sampler into the soil matrix and to lock the sampler after collection. Three Viton® O-rings, two on the plunger and one on the cap, seal the sampler preventing the loss of VOCs. Each En Core® sampler is packaged in an airtight, resealable foil package to prevent contamination during storage and shipping.

Prepare the En Core® sampler in accordance with the manufacturer's recommendations. **The plunger bottom must be flush with the bottom of the coring body <u>before</u> sampling**. This prevents air from being trapped behind the sample during coring. Trapped air can potentially cause a loss of VOCs when air passes through the sample. If air is trapped behind the sample, it may cause the sample to be prematurely expelled from the coring device.

Use of En Core® sampler is ideal for reducing the handling of preservation chemicals in the field. The practice of immediate field preservation of samples can lead to the creation of hazardous materials if all samples are not sent for laboratory analysis. The En Core® sampler can be effectively used during soil boring operations to store samples on-site until field analytical results are available, potentially reducing the number of samples sent for laboratory analysis. Upon review of the field analytical results, the field sampler can either extrude the soil stored in the En Core® sampler into the appropriate containers or retained in the En Core® sampler for later shipment to the laboratory. If an En Core® sampler is used to ship a soil sample directly to the laboratory for VOC analysis, the soil must be extruded from the En Core® sampler and preserved by the laboratory within 48 hours of sample collection.

The En Core® sampler cannot be used on cemented or consolidated materials, or, coarse materials large enough to interfere with proper coring techniques.

The En Core® sampler is a single use sampling and storage device and can not be decontaminated for reuse. The T-handle and laboratory-extruding device can be decontaminated and reused.

6.2.7.3 VOC Soil Sample Collection Technique

Small-diameter core samplers should be selected based upon the properties of the matrix, the type of preservation method (field vs. lab) and personal preference. The small-diameter core sampler should fit inside the mouth of the sample container to avoid loss of sample, prevent damage to the sealing surfaces or container threads and ease the soil transfer process.

Once the sampling interval has been selected, trim off the exposed surface of the matrix to expose a fresh surface. A loss of VOCs from the surface of the matrix will occur even if the matrix has been exposed for a short period of time (during screening, etc.). Removal of the unwanted surficial material can be accomplished by scraping the matrix surface with a decontaminated spatula or trowel. Soil sampling must commence immediately once a fresh surface has been exposed.

Push the small-diameter core sampler into the matrix to collect a volume of material which will yield the required mass of sample (wet weight) as determined by the analytical method. If the small-diameter core sampler does not have a seal between the barrel and plunger, the plunger of the coring device can be pulled back, positioned flush with the opening of the barrel or completely removed allowing the open barrel of the sampler to be inserted into the matrix. If the small-diameter core sampler has a seal between the core barrel and plunger, the plunger must be flush with the end of the core barrel to avoid pushing air through the sample during collection. Depending upon the texture, depth or moisture content, the small-diameter core sampler can be inserted straight into the matrix, on an angle or multiple insertions can be made to obtain the required sample weight.

After sample collection, wipe the outside of the small-diameter core sampler to remove any excess material adhering to the barrel. Immediately open the sample container and extrude the soil core into the sample container. If present, avoid splashing any preservative out of the sample container by holding the container at an angle while slowly extruding the soil core into the sample container. Do not immerse the small-diameter core sampler into the preservative. If an En Core® sampler is to be used for storage and shipment, prepare the sampler for shipment according to manufacturers instructions (see below for additional information). Collect the required number of sample containers or En Core® samplers based on the chosen preservation

and analytical methods as discussed in section 6.2.7.4., *VOC Soil Sample Preservation Methods*. Include an additional sample volume for percent moisture determination and sample screening as discussed in the sections below.

Ensure the threads and cap of the sample container or En Core® sampler are free of soil particles. Use a clean paper towel to remove soil particles from the threads and sealing surface of the sample container or En Core® sampler. The presence of soil particles will compromise the container's seal and may result in preservative or VOC loss. This loss ultimately may invalidate the sample analysis. Always make sure the sample lid is firmly secure.

Record the laboratory and field identification numbers in the field notes and on the chain of custody. Container labels with wire or rubber band attachments should be used provided they can be removed easily for sample weighing. **Do not attach any additional adhesive backed labels or tape to the sample containers unless requested by laboratory or specified in manufacturer instructions. This will increase the weight of the sample container and the laboratory will not be able to determine the sample weight.**

After sample collection, immediately return the containers to an iced cooler. Sample containers from different locations should be placed in separate ziplock bags to help avoid cross contamination. The laboratory sample number or field sample identification number may be placed on the bag and crossed referenced on the chain of custody. The laboratory performing the analysis will determine the sample weight.

If the laboratory has determined a sample container has leaked by noting a visible reduction in preservative or unusually low weight, the sample may be rejected for analysis by the laboratory. The sampling team leader or project manager must be notified immediately of any problems with the sample condition. Only the suspect vial will be in question, not the entire sample shipment.

6.2.7.4 VOC Soil Sample Preservation Methods

The preservation of samples for VOC analysis can be initiated either at the time of sample collection or in the laboratory. This section deals with the preservation of soil samples for VOC analysis in the field using chemical and physical preservation methods. Please note the first three preservation methods (1 through 3) are preferred sample preservation method under the, *USEPA Contract Lab Program (CLP) Statement of Work (SOW) for Organic Analysis, Multi-Media, Multi-Concentration*. The last three preservation methods (4 through 6) though not preferred are acceptable under specific circumstances as outline below.

It is important that the laboratory analytical methods, field preservation methods, appropriate sample containers and sample holding times are determined and agreed upon prior to mobilizing to the field. Also, additional sample containers maybe required for various quality control/quality assurance (QA/QC) samples such as matrix-spike and matrix-spike duplicates (MS/MSD). The number of extra containers required vary by laboratory and analytical procedure. It is up to the laboratory and sampling team to determine the required number of containers for each QA/QC sample submitted.

In addition to the various chemical preservation methods, samples must be physically preserved (e.g. iced or frozen) in the field immediately upon sample collection. Physical preservation methods such as "icing" or freezing" are accomplished by placing sample containers in insulated coolers containing "wet ice", "blue ice" or "ice gel packs". It is important to match up the correct physical preservation method with the appropriate sample container and field chemical

preservation method. According to USEPA CLP Guidance for Field Samplers, the physical preservation methods are described as:

Iced – soil and sample containers are cooled to 4°C (± 2°C)
Frozen – soil and sample containers are cooled to between -7°C and -15°C

Sample containers, which will be frozen, should be placed on their side prior to freezing process to prevent breakage. Additional aliquots for screening and moisture determination need only be iced and kept cooled at 4°C (± 2°C): these sample containers should not be frozen. ***Sample containers and En Core® sampler should not be frozen below -20° C as the integrity of the container seals, o-rings and septum may be compromised by the freezing, resulting in the loss of VOCs upon sample thawing.***

In addition, the use of dry ice to freeze samples immediately upon sample collection or for use during shipment is not recommended. Dry ice, which is at a temperature of -78.5°C, will lower the temperature of the sample container below the design specifications causing damage to the glass, septum, seals o-rings and cap. In addition, dry ice has specific handling, storage and shipping requirements that far out-way its usefulness to the field sampling team.

6.2.7.4.1 Closed-System Vials, No Chemical Preservation

This preservation and sampling method employs the use of tared, un-preserved 40-ml glass vials with PTFE-lined septum screw cap and a magnetic stir bar. A minimum of three (3) sample containers with a stir bar must be used for each sample location. An additional sample aliquot is also necessary for screening and moisture determination. ***This is a preferred method of preservation by USEPA CLP SOW.***

Using a small-diameter core sampler as described above, 5-grams of soil should be placed in each of the vials. Care must be taken when placing the soil in the vial to limit loss of soil. Each vial must also contain a clean magnetic stir bar. If the laboratory instrumentation has a sonicator or other mechanical means of mixing the sample, the stir bar may be omitted.

Vials (with stir bars and septum caps) must be tared (or weighed) before use. Each sample vial should be weighed by the laboratory (to the nearest 0.01 grams) and by field personnel (to the nearest 0.1 grams). After soil, has been placed in the vial, the vial should be capped, wiped clean and reweighed. The pre- and post-sampling weights should be recorded in bound logbook, chain of custody or electronic file with the corresponding numerical designation and supplied to the laboratory.

The vials should also have a label affixed by the laboratory or vendor with a unique numerical designation which corresponds to associated table of tared weights for each vial. The weight of any markings added to this label in the field is negligible. However, additional labels should not be attached to the vial by the field sampling personnel. If needed an easily removable tag may be attached by wire or string to the neck of the vial. After sample collection, the vials should be iced (cooled to 4°C [± 2°C]) or frozen (-7°C and -15°C) for later shipment to the laboratory. The holding time for non-chemically preserved, iced (cooled to 4°C [± 2°C]) and frozen (-7°C and-15°C) samples is 48 hours from sample collection to chemical preservation, freezing or analysis by the laboratory. The holding time for soil sample can be extended to 14 days if the soil is chemically preserved or kept frozen or until actual analysis. This

method is appropriate for low- and medium-level analysis under USEPA CLP SOW and low- and high-level analysis for USEPA SW846 Methodologies.

In addition, the sample containers must be stored in a contaminant free environment before use and during shipment. It is the responsibility of the field sampling team and sample container provider to ensure contaminant free sample container integrity. The analytical laboratory or a vendor can supply sample containers with a stir bar.

Disadvantages

- Increased possibility of breakage during shipment due to freezing the sample below -20 ^{o} C.
- Difficult to maintain freezing temperatures (-7^{o}C and -15^{o}C) in the field or during shipment.
- A 48 hour holding time for non-chemically preserved, soil samples cooled to 4^{o}C ($\pm$ 2^{o}C) or frozen (-7^{o}C and -15^{o}C) require the laboratory to chemically preserve, freeze or analyze the samples quickly.

6.2.7.4.2 Closed-System Vials, No Chemical Preservation with Organic Free Water (OFW)

This preservation and sampling method employs the use of tared, un-preserved 40-ml glass vials with PTFE-lined septum screw cap, a magnetic stir bar and reagent water (organic free water-OFW). A minimum of two (2) sample containers must be prepared with the required OFW and stir bar for each sample location. The USEPA CLP Guidance for Field Samplers also recommends collecting one additional vial without OFW for backup analysis. Additional sample aliquot is also necessary for screening and moisture determination. ***This is a preferred method of preservation by USEPA CLP SOW.***

Using a small-diameter core sampler, 5-grams of soil should be placed in each of the vials. Care must be taken when placing the soil in the vial to limit splashing or loss of the OFW. The volume of OFW is dependent upon the analytical method, however USEPA CLP SOW recommends 5ml of water for each vial collected. Each vial must also contain a clean magnetic stir bar. If the laboratory instrumentation has a sonicator or other mechanical means of mixing the sample, the stir bar may be omitted.

Vials with OFW (with stir bars and septum caps) must be tared (or weighed) before use. Each sample vial should be weighed by the laboratory (to the nearest 0.01 grams) and by field personnel (to the nearest 0.1 grams). Once the OFW and/or stir bar is added to the vial by the laboratory or vendor, a mark can be made on the vial corresponding to the level of the liquid meniscus to assist the field personnel in determining if OFW has been lost from the vial. Prior to placing the soil in the vial, each sample vial should be weighed by the field personnel to check on the potential loss of OFW. The loss of greater than 0.2 grams is an indicator that OFW has been lost and the vial must not be used for sampling. After soil, has been placed in the vial, the vial should be capped, wiped clean and reweighed. The pre- and post-sampling weights should be recorded in bound logbook, chain of custody or electronic file with the corresponding numerical designation and supplied to the laboratory.

The vials with OFW should also have a label affixed by the laboratory or vendor with a unique numerical designation which corresponds to associated table of tared weights for each vial. The weight of any markings added to this label in the field is

negligible. However, additional labels should not be attached to the vial by the field sampling personnel. If needed an easily removable tag may be attached by wire or string to the neck of the vial. Record the lot number of the preservative used in the preparation of the sample containers. This information can be used for future reference in the event of suspected contamination. After sample collection, the vials should be iced (cooled to 4°C [± 2°C]) or frozen (-7°C and -15°C) for later shipment to the laboratory. The holding time for non-chemically preserved, iced (cooled to 4°C [± 2°C]) and frozen (-7°C and -15°C) samples is 48 hours from sample collection to chemical preservation, freezing or analysis by the laboratory. The holding time for soil sample can be extended to 14 days if the soil is chemically preserved or kept frozen or until actual analysis. This method is appropriate for low- and medium-level analysis under USEPA CLP SOW and low- and high-level analysis for USEPA SW846 Methodologies.

In addition, sample containers must be stored in a contaminant free environment before use and during shipment. It is the responsibility of the field sampling team and sample container provider to ensure contaminant free sample container integrity. The pre-preserved sample containers with OFW and a stir bar can be supplied by the analytical laboratory or a vendor.

Disadvantages

- Increased costs due to the addition of a preservative and magnetic stir bar into each sample container.
- Increased possibility of breakage during shipment due to freezing the sample below -20 ° C.
- Difficult to maintain freezing temperatures (-7°C and -15°C) in the field or during shipment.
- A 48 hour holding time for non-chemically preserved, soil samples cooled to 4°C (± 2°C) or frozen (-7°C and -15°C) require the laboratory to chemically preserve, freeze or analyze the samples quickly.

6.2.7.4.3 Small Diameter Core Sampler for Storage and Transport (e.g., En Core® Sampler)

This preservation and sampling method employs the use of a small-diameter core sampler known as the En Core® sampler. The En Core® sampler is a one-time-use, volumetric sampling, storage and transportation device. It is designed to collect and store soil samples for transportation to the laboratory. (See previous discussion on use of the En Core® sampler as a sample collection tool.) ***This is a preferred method of preservation by USEPA CLP SOW.***

Please note: Prior to using any other small-diameter core sampler not mentioned here for storage and transportation to the laboratory, a comparison data and an equivalency study must be provided to NJDEP in accordance with N.J.A.C. 7:26E-1.6(c) and deemed acceptable by the NJDEP.

Soil should be collected using the En Core® sampler in accordance with the manufacturer's recommendations. A specially designed "T" handle, available from the manufacturer, is used to push the En Core® sampler into the soil matrix and to lock the sampler after collection.

A minimum of three (3) individual 5-gram En Core® samplers must be collected for each soil sample. Upon sample collection, label each En Core® sampler cap with the label provided by the manufacturer and return it to the airtight, resealable foil package. Additional sample aliquot is also necessary for screening and moisture determination as discussed below. En Core® samplers should be iced (cooled to 4°C [± 2°C]) or frozen (-7°C and -15°C) for later shipment to the laboratory. En Core® samplers can be shipped directly to the laboratory for VOC analysis; however, laboratory must extrude the soil from the En Core® sampler and analyze, chemically preserve or freeze the soil within 48 hours of sample collection. The soil samples must be extruded from the En Core® sampler into appropriate sample containers using a specially designed "T" handle push-rod tool available from the manufacturer. Soil **can not** be scooped out of the En Core® sampler using a trowel or spatula as this can cause a significant loss of VOCs. The holding time for soil stored in an En Core® sampler can be extended if the soil is extruded by the laboratory within 48 hours to a sealed vial and frozen or chemically preserved until actual analysis. This method is appropriate for low- and medium-level analysis under USEPA CLP SOW and low- and high-level analysis for USEPA SW846 Methodologies.

En Core® samplers must be stored in a contaminant free environment before use and during shipment. It is the responsibility of the field sampling team and sample container provider to ensure contaminant free sample container integrity. The En Core® samplers can be supplied by the analytical laboratory or a vendor.

Disadvantages

- The En Core® sampler cannot be used on cemented or consolidated materials, or, coarse materials large enough to interfere with proper coring techniques.
- Any "alternative" to the En Core® sampler must have a plunger to allow for proper mechanical dispensing at the laboratory, and must be approved for use by NJDEP.
- A 48 hour holding time for non-chemically preserved, soil samples cooled to 4°C (± 2°C) or frozen (-7°C and -15°C) require the laboratory to chemically preserve, freeze or analyze the samples quickly.
- Currently the En Core® sampler is the only small-diameter core sampler approved for use by NJDEP for sampling, storage and transport.
- Difficult to maintain freezing temperatures (-7°C and -15°C) in the field or during shipment.

6.2.7.4.4 Closed-System Vials, Chemical Preservation – Sodium Bisulfate

This preservation and sampling method employs the use of tared, pre-preserved 40-ml glass vials with PTFE-lined septum screw cap, a magnetic stir bar and sodium bisulfate (ACS reagent grade or equivalent). A minimum of two (2) sample containers must be prepared with the required preservative and stir bar for each sample location. The USEPA CLP Guidance for Field Samplers also recommends collecting one additional un-preserved vial for backup analysis. Additional sample aliquot is also necessary for screening and moisture determination.

Using a small-diameter core sampler, 5-grams of soil should be placed in each of the 40-ml vials (with or without preservative). Care must be taken when placing the soil in the vial to limit splashing or loss of the preservative. The volume of sodium

bisulfate is dependent upon the analytical method, however USEPA CLP SOW recommends 1 gram of sodium bisulfate in 5ml of water for each vial collected. Each vial must also contain a clean magnetic stir bar. If the laboratory instrumentation has a sonicator or other mechanical means of mixing the sample, the stir bar may be omitted.

Pre-preserved vials (with stir bars and septum caps) must be tared (or weighed) before use. Each sample vial should be weighed by the laboratory (to the nearest 0.01 grams) and by field personnel (to the nearest 0.1 grams). Once the preservative and/or stir bar is added to the vial by the laboratory or vendor, a mark can be made on the vial corresponding to the level of the liquid meniscus to assist the field personnel in determining if preservative has been lost from the vial. Prior to placing the soil in the vial, each sample vial should be weighed by the field personnel to check on the potential loss of preservative. The loss of greater than 0.2 grams is an indicator that preservative has been lost and the vial must not be used for sampling. After soil, has been placed in the vial, the vial should be capped, wiped clean and reweighed. The pre- and post-sampling weights should be recorded in bound logbook, chain of custody or electronic file with the corresponding numerical designation and supplied to the laboratory.

The pre-preserved vials should also have a label affixed by the laboratory or vendor with a unique numerical designation which corresponds to associated table of tared weights for each vial. The weight of any markings added to this label in the field is negligible. However, additional labels should not be attached to the vial by the field sampling personnel. If needed an easily removable tag may be attached by wire or string to the neck of the vial. Record the lot number of the preservative used in the preparation of the sample containers. This information can be used for future reference in the event of suspected contamination. After sample collection, the vials should be iced (cooled to 4^{o}C [$\pm$ 2^{o}C]) for later shipment to the laboratory. The holding time for chemically preserved, iced (cooled to 4^{o}C [$\pm$ 2^{o}C]) samples is 14 days from sample collection to analysis by the laboratory. This method is appropriate for low- and medium-level analysis under USEPA CLP SOW and low- and high-level analysis for USEPA SW846 Methodologies.

This is not a preferred method of preservation by USEPA CLP SOW. Sodium bisulfate preservation of soil may result in the destruction or creation of certain target VOCs. As a result, sodium bisulfate should not be used in the following circumstances:

- If contaminants of concern include VOCs such as vinyl chloride, trichloroethene, styrene, 2-chloroethylvinyl ether, trichlorofluoromethane, or cis- and trans-1, 3-dichloropropene. Low pH conditions caused by the preservation of soil with sodium bisulfate cause the destruction or breakdown of these VOCs resulting in biased low analytical data.
- Soils with a higher proportion of decayed matter where acetone is a contaminant of concern should not be preserved with sodium bisulfate. Decomposition of the decayed matter due to sodium bisulfate preservation results in the creation of a false positive acetone artifact yielding biased high analytical results.

- If the soils contain carbonaceous material. The carbonaceous material present in the soil, either natural or amended, will react with the sodium bisulfate and cause the sample to effervesce resulting in a loss of VOCs.

Pre-preserved sample containers must be stored in a contaminant free environment before use and during shipment. It is the responsibility of the field sampling team and sample container provider to ensure the container's contaminant free integrity. The pre-preserved sample containers with stir bar can be supplied by the analytical laboratory or a vendor.

Disadvantages

- Sodium bisulfate can not be used on carbonaceous soils as effervescence may ensue with subsequent VOC loss.
- Sodium bisulfate creates low pH conditions that may result in the destruction of certain target VOCs.
- Increased costs due to the addition of a preservative and magnetic stir bar into each sample container.

6.2.7.4.5 Closed-System Vials, Chemical Preservation – Methanol

This method employs the use of tared, pre-preserved 40-ml glass vials with PTFE-lined septum screw cap and methanol (purge and trap quality grade or equivalent). A minimum of two (2) sample containers must be prepared with the required preservative. Additional sample aliquot is also necessary for screening and moisture determination.

Using a small-diameter core sampler, 5-grams of soil should be placed in each of the 40-ml pre-preserved vials. Care must be taken when placing the soil in the vial to limit splashing or loss of the preservative. The volume of methanol is dependent upon the analytical method. The USEPA CLP SOW recommends 5 to 10 ml of methanol in each vial collected.

Pre-preserved vials (with septum caps) must be tared (or weighed) before use. Each sample vial should be weighed by the laboratory (to the nearest 0.01 grams) and by field personnel (to the nearest 0.1 grams). Once the preservative is added to the vial by the laboratory or vendor, a mark can be made on the vial corresponding to the level of the liquid meniscus to assist the field personnel in determining if preservative has been lost from the vial. Prior to placing the soil in the vial, each sample vial should be weighed by the field personnel to check on the potential loss of preservative. The loss of greater than 0.2 grams is an indicator that preservative has been lost and the vial must not be used for sampling. After soil, has been placed in the vial, the vial should be capped, wiped clean and reweighed. The pre- and post-sampling weights should be recorded in bound logbook, chain of custody or electronic file with the corresponding numerical designation and supplied to the laboratory.

The pre-preserved vials should also have a label affixed by the laboratory or vendor with a unique numerical designation which corresponds to associated table of tared weights for each vial. The weight of any markings added to this label in the field is negligible. However, additional labels should not be attached to the vial by the field sampling personnel. If needed an easily removable tag may be attached by wire or

string to the neck of the vial. Record the lot number of the preservative used in the preparation of the sample containers. This information can be used for future reference in the event of suspected contamination. After sample collection, the vials should be iced (cooled to 4°C [± 2°C]) for later shipment to the laboratory. The holding time for chemically preserved, iced (cooled to 4°C [± 2°C]) and samples is 14 days from sample collection to analysis by the laboratory. This method is appropriate for medium-level analysis under USEPA CLP SOW and high-level analysis for USEPA SW846 Methodologies.

This is not a preferred method of preservation by USEPA CLP SOW. Methanol preservation of soil results in higher detection limits and is therefore not applicable to low-level analysis. Additional problems associate with the use of methanol include:

- Soils with high moisture content (>10 %) that are field preserved with a water miscible solvent such as methanol are diluted by the total volume of the solvent/water mixture. The detected contaminant concentrations must be corrected to account for the solvent/water dilution factor. If this calculation is not made, the additional dilution by soil pore water will result in biased low analytical data.
- Leakage of methanol from the container during sampling or in shipment causing the loss of VOCs in the methanol and resulting in biased low analytical data.
- Possible contamination of methanol by other sampling related activities including the absorption of diesel fumes from running equipment or vehicles on to the sample containers.
- The preservation of soil by methanol results in the re-classification of the sample as a hazardous waste. This hazardous waste classification results in increased shipping and disposal costs.

Pre-preserved sample containers must be stored in a contaminant free environment before use and during shipment. It is the responsibility of the field sampling team and sample container provider to ensure contaminant free sample container integrity. The pre-preserved sample containers can be supplied by the analytical laboratory or a vendor.

Disadvantages

- Methanol preservation is applicable to medium and high level analysis only. Low-level concentrations not detectable with this preservation method.
- Biased low analytical data due to the loss of methanol after sampling or high moisture content in the soil.
- Increased costs due to the addition of a preservative and the classification as a hazardous waste resulting in higher shipping and sample disposal costs.

6.2.7.4.6 Glass Containers, No Chemical Preservation, No Headspace

This preservation method employs the use of un-preserved-glass sample containers with a PTFE-lined screw cap. A minimum of two 4-oz glass containers must be used for each soil sample. Soil should be placed in the containers using decontaminated stainless steel spoons or spatulas in such a manner as to minimize the headspace (e.g. the containers must be completely filled). Additional sample aliquot is also necessary for screening and moisture determination as discussed below. The samples are then

iced and cooled to 4°C (±2°C) for later shipment to the laboratory. The holding time for non-chemically preserved, cooled to 4°C (±2°C) soil samples is 48 hours from sample collection to preservation or analysis in the laboratory. This method is appropriate for low- and medium-level analysis under USEPA CLP SOW and low- and high-level analysis for USEPA SW846 Methodologies.

This is not a preferred method of preservation by USEPA CLP SOW as losses of VOCs from biodegradation and volatilization may occur when the sample containers are opened in the laboratory. Due to the configuration of the container as the volume of soil within, the laboratory must open the container to remove the required sample volume for analysis. Studies had shown that substantial loss of VOCs occur during this laboratory procedure. However, circumstances exist where chemical preservation or freezing is not recommended. In these instances best professional judgement must be used in the selection of this method as pursuant to N.J.A.C. 7:26E-1.6(c). The circumstances which may result in the use of this method include:

- Waste characterization sampling under Subtitle C of RCRA, the use of specific test methods for some applications are required in 40 CFR parts 260 through 270.
- Sampling unknown wastes or oily wastes (from containers, drums, etc.) when the reactivity of the waste with chemical preservative or freezing is not known. After initial laboratory analysis has characterized the waste, subsequent sampling using preservation can be performed if the waste is found to be non-reactive to the chemical preservative.
- During emergency response actions when there is no time for prepared sample containers to arrive from the laboratory. Re-sampling of potential impact areas may be required using approved preservation procedures after the emergency has been mitigated.

Sample containers must be stored in a contaminant free environment before use and during shipment. It is the responsibility of the field sampling team and sample container provider to ensure contaminant free sample container integrity. The sample containers can be supplied by the analytical laboratory or a vendor.

Disadvantages:

- Potential loss of VOCs when the sample containers are opened at the laboratory.
- Biased low analytical results due to the loss of VOCs.
- Holding time of 48 hours for non-chemically preserved, soil samples cooled to 4°C (± 2°C) requires the laboratory to preserve or analyze samples quickly.

6.2.7.5 Sample Aliquot for Moisture Determination and Sample Screening

This sample aliquot will be used for laboratory screening and percent moisture analysis. They will first screen the sample to determine the appropriate analytical level of analysis, which will be dictated by the concentration of VOCs in the sample. To accommodate the laboratory's preparatory steps, additional sample matrix must be provided to the laboratory from each sample location. The additional sample aliquot must be collected using a decontaminated stainless steel trowel or spatula and place into an un-preserved sample container, usually a 60-ml wide mouth PTFE-lined glass container. This sample is not chemically preserved. The sample must be obtained from the same interval and location as the sample for VOC analysis. The sample container must be completely filled with sample to minimize headspace and loss of

VOCs. The laboratory must report the analytical results for soil and sediments (non-aqueous) samples on a dry weight basis

Ensure the threads and cap of the sample container are free of soil particles by wiping with a clean or paper towel. The presence of soil particles will compromise the container's seal and may result in preservative or VOC loss. Always make sure the sample lid is firmly secure. The sample aliquot for moisture determination and sample screening must be placed and shipped on ice at 4°C (± 2°C).

6.2.7.6 Commercial Equipment Suppliers

A partial listing of equipment suppliers for sampling equipment is included in Table 6.10. This listing of equipment suppliers is not an endorsement by the New Jersey Department of Environmental Protection; it is supplied for information purposes only.

Table 6.10 Discrete Soil Sampler Suppliers

Discrete Soil Sampler	Supplier
Purge and Trap Soil Sampler®	Associated Design and Mfg. Co. 814 N. Henry St. Alexandria, VA 22314-1619 703-549-5999
En Core® Sampler Terra Core Sampler® Easy-Draw Syringe® and Power Stop Handle	En Novative Technologies 1241 Bellevue St. Green Bay, WI 54302 1-888-411-0757
10-cc Syringes	J&H Berge, Inc. 4111 South Clinton Ave. South Plainfield, NJ 07080 1-908-561-1234 VWR Scientific Products P.O. Box 369 405 Heron Drive Swedesboro NJ 08085 856-467-2600 Thomas Scientific 99 High Hill Road @I-295 P.O. Box 99 Swedesboro, NJ 08085 856-467-2000

6.2.8 Non-VOC Sample Collection for Soils

Contaminants such as semivolatile organic compounds (SVOCs), pesticides, PCBs, metals or cyanide that cannot be detected with field screening instrumentation must be sampled from locations or depths that are most likely to be contaminated. These locations should be based on the location and nature of the discharge or type of matrix to which the contaminant was discharged. The sampler should include in the logbook any information noted during sampling activities that

aided in the determination of non-VOC sample location selection. This will ensure accurate data interpretation by non-field personnel at a later time.

It is important that the laboratory analytical methods, field preservation methods, appropriate sample containers and sample holding times are determined and agreed upon by the sampling team and laboratory prior to mobilizing to the field. Also, additional sample containers maybe required for various quality control/quality assurance (QA/QC) samples such as MS/MSDs. The number of extra containers required vary by laboratory and analytical procedure. It is up to the sampling team to know the required sample volume and number of containers for each QA/QC sample submitted.

In instances where a soil is collected for VOC analysis as well as other non-VOC parameters, the soil for VOC analysis must be collected first to minimize volatilization and biodegradation. Once VOC soil sampling is complete the remaining soil to be analyzed for non-VOC parameters such as SVOCs, pesticides, PCBs, metals or cyanide must be homogenization to create a representative sample. In case of limited sample quantity, prioritization of analytical parameters should be determined beforehand by the project leader or case manager.

Homogenization or mixing of the soil with a decontaminated spoon or spatula can take place either in-situ (in the case of shallow soil sample) or in a decontaminated stainless steel bowl or tray. The bowl or tray must be large enough to hold more than the required sample volume and to allow proper mixing without spillage. It is important that mixing of soil be as thorough as possible. The mixing technique will depend on the physical characteristics of the soil including moisture content, particle size and distribution however, the goal is to achieve a consistent physical appearance over the entire soil sample. Prior to homogenization, twigs, roots, leaves, rocks and miscellaneous debris (glass, bricks, etc.) should be removed from the sample using the decontaminated stainless steel spoon or spatula. Care should be taken to minimize contact of disposable gloves with soil to be sent for laboratory analysis.

Homogenization of the soil includes a series of mixing and quartering steps. The soil should be scraped from the sides, corners and bottom, rolled into the middle of the decontaminated stainless steel bowl or tray (or in-situ hole) and mixed. The soil should then be quartered (divided into 4) and moved to the sides of the bowl/tray/hole. Each quarter should then be mixed individually, and then rolled to the center of the bowl/tray/hole and mixed with the entire sample again. These steps of quartering the soil, mixing individually and then mixing the entire sample again should be repeated at least twice. Once a consistent physical appearance over the homogenized soil has been obtained, the soil should be transferred into the appropriate sample container using the decontaminated stainless steel spoon or spatula.

Once the sample containers are full, ensure the threads, lid and outer edges of the sample container are free of soil particles. Use a clean paper towel to remove soil particles from the threads and sealing surface of the sample container. The presence of soil particles will compromise the container's seal and may result in loss of soil moisture, cross contamination or the lid opening in transit. Always make sure the container lid is firmly secure.

After sample collection, immediately return the container to an iced cooler in an upright position. Sample containers from different sample locations should be placed in separate ziplock bags to protect other containers in case of leakage during transport. The laboratory sample number or field sample identification number may be placed on the bag and crossed referenced on the chain of custody. Record the laboratory and field identification numbers in the field notes and on the chain of custody. The laboratory performing the analysis will determine percent moisture.

6.2.9 Sampling Alternatives for Situational and Matrix Variations

Sample collection procedures discussed above are appropriate in a majority of cases. However, situational or matrix variations require some modification to the sampling methods. Documentation of using any alternative sampling procedures is critical to aid in data interpretation. The data generated from non-core samples must be used with caution due to the potential for significant VOC loss. Anytime a coring device is not used for VOC sample collection an explanation of the procedure and reasons for its use must be provided to the Department.

6.2.9.1 Sampling Hard or Cemented Material

Sampling of cemented materials may be too hard to allow sample collection via previously discussed methods. Therefore other techniques may be employed. Collecting a sample of this material can be performed by fragmenting the sample with a decontaminated chisel to generate aggregate of material for placement into the sample container. Caution is warranted due to potential injury when performing sampling using this method due to flying particles during the fragmentation process. The aggregate material can be transferred to the sample container with the use of a stainless steel spatula or small trowel. A small funnel can be used to channel the sample into the container. The funnel must not restrict the passage of the larger pieces of sample aggregate. Loss of VOCs may occur when sampling this matrix during the fragmentation process and the increased exposure of surface area of the material.

6.2.9.2 Sampling a Mixture of Fines and Gravel

Sampling of poorly sorted material consisting of large aggregate and fines may not allow a core sampler to be used. In these conditions, a stainless steel spatula or trowel can be used for sample collection. The sample collection process must be performed quickly to prevent a loss of VOCs. A small funnel can be used to channel the sample into the container. The funnel must not restrict the passage of the larger pieces of sample aggregate. A separation of coarse and fine-grained material will be inherent to the process, which will bias the data due to non-representation of all size material. As a result, data generated from samples of this matrix must be used with caution. Loss of VOCs may occur when sampling this matrix due to the increase exposure of surface area of the material.

6.2.9.3 Sampling Dry Non-Cohesive Material

For material such as dry sand, packing a cohesive plug will be very difficult. In these situations, obtain a core sample or push the sample into the barrel of the sampler with a spatula, packing the sample into the barrel. Then cover the opening of the core sampler with the spatula so the material does not fall out of the sampler until the material is extruded into the sample container. A small funnel can be used to channel the sample into the container. The funnel must not restrict the passage of the larger pieces of sample aggregate. Loss of VOCs may occur when sampling this matrix due to the increased exposure of surface area of the material.

6.2.9.4 Sampling Sediments

When sampling sediment, a wide variety of materials may be encountered. The matrix may include fine grained material, a mixture of coarse and fine grained material which may include dead vegetative material (leaves, sticks, etc.) or peat moss. The bulk sampling of sediments can be collected with a core sampler or clamshell dredge. The method of collecting the discrete sample will depend upon the type of material encountered. Therefore, various sampling tools must be available to ensure the collection of representative samples.

One of the problems encountered when sampling sediments is the amount of water in the sample. The high level of moisture will increase the detection limits of the analysis due to the concentration calculation on a dry weight basis.

In some cases the density of the material may not allow a sample to be collected within the required weight range of the analytical method or the required weight of material may not be fully submerged in the preservative. These cases may require the addition of preservative by the laboratory to submerge the sample which will increase the detection limits of the sample.

6.2.9.5 Sampling Oil Waste, Tars and Other Waste Material

The collection of a discrete waste sample may be successful using one of the methods mentioned previously. The type of material will dictate the best sampling method. If none of the discrete core sampling methods is applicable to the matrix, then a sample can be collected in an unpreserved glass sample container with a PTFE lined lid. Headspace in the container must be minimized. The laboratory will collect a sub-sample from the material for analysis. Documentation of using this sampling procedure is critical to aid in data interpretation. Loss of VOCs may occur when sampling this matrix due to the increased exposure of surface area of the material.

6.2.9.6 Sampling from Test Pits

Test pit excavation is useful in the identification of waste material buried on site and for direct observation of the soil horizons for any apparent band of soil contamination. However, this method does have limitations. Due to the amount of disturbance involved, test pit samples are not reproducible and are not considered to represent the undisturbed formation. Additionally, equipment, visual observation, distance and the integrity of the trench walls limit the depth of the evacuation. The health and safety hazard associated with test pits is great. Because the trench walls may be unstable, no personnel should enter any test pit that is deeper than three (3) feet. Care must be taken in working near the backhoe. All personnel must be alert to the machine's movement and be prepared for any potential contaminant release from the excavation. During test pit operations, the potential exists to leave contaminated soils at the surface where it may not have been present before excavation. Consideration must be given to potential exposures from the contaminated surface soils. Finally, in areas where surface soil contamination is a problem, this contamination may be carried deeper by excavation and backfilling. In such a situation test pits should not be used.

For these reasons, test pits should only be used as a sampling approach to locate specific hot spots of contamination or to locate specific buried waste. To most efficiently collect representative soil samples at depth, a drill rig or direct push should be used.

If it is determined that test pits will be utilized to access samples at depth, the backhoe used must be equipped with a protective shield and its operator properly trained in the use of level B respiratory and dermal protection. The backhoe bucket and arm must be thoroughly decontaminated by steam cleaning or standard cleaning procedures for non-aqueous sampling equipment prior to use and between each test pit location.

The operator should be directed to excavate until the sampler indicates that the desired depth has been reached. All excavated material should be placed on a tarp or plastic sheeting. If the pit is shallow (less than three feet) the sampler can enter the pit and collect the soil sample using a decontaminated trowel for non-VOCs or small a diameter soil coring device. As the pit gets deeper, the sampler may collect the soil directly from the bucket of the backhoe in an area where the sample material is not in contact with the bucket. The sample should be transferred

from the bucket following appropriate collection techniques for each analytical parameter to be analyzed.

6.3 Rock Core Sample Collection

The Technical Requirements for Site Remediation require, if appropriate, that rock cores be collected during the drilling of bedrock monitoring wells, piezometers and other borings [N.J.A.C., 7:26E-4.4(g)5].

Rock core drilling is a drilling method that can provide core samples of the bedrock under investigation. The core samples can be obtained from specific depth intervals. Rock coring is conducted in materials that are too hard to permit the use of direct-push or split-spoon coring techniques.

Since core samples provide an actual rock sample, the geologist can observe and evaluate the true character of the bedrock material (Wells 1991). The evaluation can include analyses and descriptions of lithologies, rock textures, stratigraphy, bedding plane structure, fracture characteristics, primary and secondary porosities, permeability, rock fluids, and contaminant content.

6.3.1 Coring Methods

There are two fundamental rock-coring methods: drill string coring and wireline coring.

6.3.1.1 Drill String Coring

Drill string coring is a procedure where the core sample is obtained from the bottom of the borehole. This sampling is accomplished by attaching tube-type coring equipment to the end of the drill string. The core sample is obtained while the coring device drills the borehole.

6.3.1.2 Wireline Coring

Wireline coring techniques utilize a cable to lower and/or raise the coring tools through an existing borehole. The coring tools used in wireline coring can be either tube-type tools or sidewall coring tools. Wireline coring is generally faster and less costly than drill string coring methods.

6.3.2 Coring Tools

6.3.2.1 Tube-Type Coring Tools

Tube-type coring tools can be either a single or double-tube design (Lapham, et. al., 1997). Most rock coring operations associated with ground-water remedial investigation work is completed using double-tube coring tools and drill string coring methods. Double-tube coring tools basically consist of a rotating outer sleeve with a circular diamond coring bit and a swivel-mounted stationary inner sleeve (i.e., core barrel) (Figure 6.1). Usually double-tube coring tools are constructed in 30-foot lengths.

Tube-type coring provides a continuous vertical section of the formation under study. During the coring procedure the outer sleeve simultaneously drills the borehole and cuts the core sample. As the coring tool descends, the core sample is pushed into the stationary inner barrel. The core sample is held in place by a core retaining device (a.k.a. core lifter). When the inner sleeve is full, the drill string and coring tool are pulled from the borehole to permit core recovery. The core barrel can also be extracted from the cutting tool and borehole by means of wireline methods.

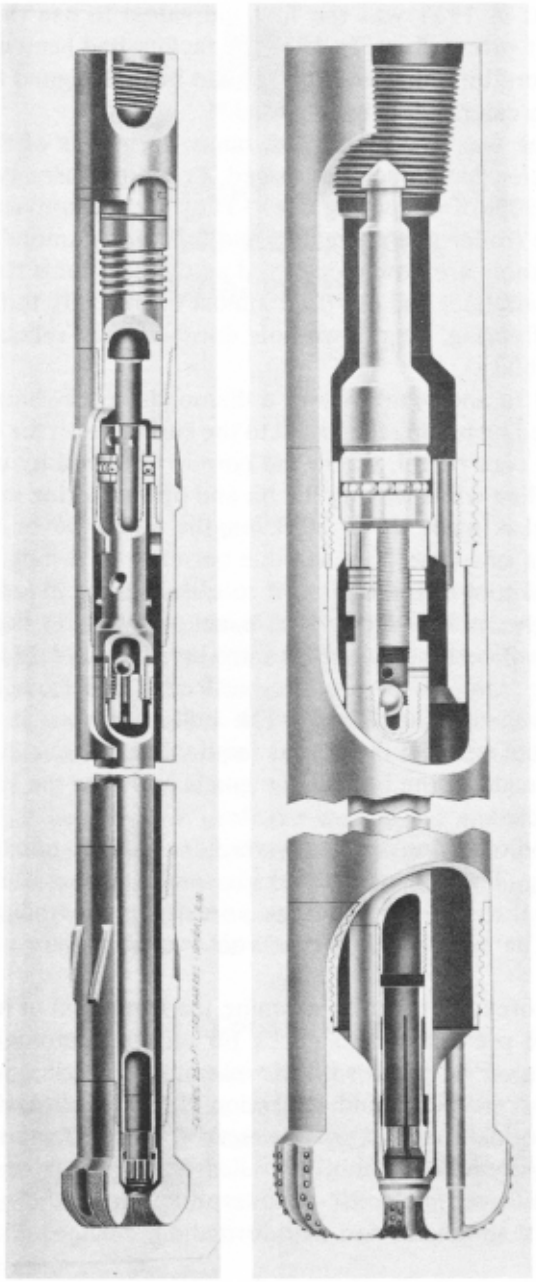


Figure 6.1 Double tube coring tool. Anderson, 1975, printed with permission.

Figure 6.2 Impregnated diamond bit. Acker, 1974, printed with permission.

Descriptions of specifications for various types of tube-type tools can be found in the ASTM standard practice reference designation D 2113-83, "Practice for Diamond Core Drilling for Site Investigation."

Most conventional coring tools are fitted with a circular diamond core bit (Figure 6.2). Diamond core bits consist of a diamond-impregnated, hardened matrix. The circular shape allows a core sample to pass into the core barrel during the drilling operation. A detailed discussion of the various types of bits and their applications can be found in Acker, 1974.

The main disadvantage of tube coring is the high cost.

6.3.2.2 Sidewall Coring Tools

Sidewall coring tools obtain core "plugs" from the side of the existing borehole by means of either explosive charges detonated at predetermined depths or by use of a rotating core bit. Since these tools are generally run into the borehole on a wireline, the core sample plugs are extracted by removing the tool from the borehole with the cable.

Sidewall coring is faster and less expensive than conventional coring methods. In addition, sidewall core samples can be taken from predetermined zones of interest and over a large borehole interval. Sidewall methods are often employed to verify and correlate the results of downhole electric and nuclear logging procedures.

The explosive method of sidewall sample collection often causes compression and distortion of the material's structural integrity. Consequently, the accuracy of structural and permeability analyses is compromised.

Sidewall coring methods were developed for the petroleum industry and are not generally employed for use in ground-water remedial investigations.

6.3.2.3 Oriented Coring Tools

Oriented core samples can be used to obtain strike and dip data for fractures, bedding, joints, formation contacts, and other planar features present in the bedrock. This type of information is important for use in the evaluation of contaminant fate and transport and the determination of additional well locations.

The orientation of the sample is established relative to magnetic north by means of a continuous scribe etched onto the core during the drilling process. A magnetic survey instrument that is located within the core barrel orients the scribe. Borehole inclination and directional orientation of the reference scribe on the core are also recorded on film by the survey tool.

The core analyst can later determine the orientation of the planar features by placing the core sample in a goniometer. The core sample can be physically oriented in the goniometer relative to its original position within the borehole. A sighting ring on the goniometer is then aligned so it appears as an extension of the planar feature to be measured. The strike and dip can then be determined by means of a graduated base ring and protractor mounted on the goniometer.

6.3.3 Coring Procedures

The following list contains general guidelines that should be addressed during the coring process (PSE&G SOP 310,1997):

- The borehole shall be cased through the entire thickness of any overburden present. The casing shall also be firmly seated into the bedrock prior to the coring operation.
- The coring pressure of the drilling rig shall be adjusted to maximize core recovery.
- Coring shall not be conducted with worn or damaged bits and core lifters.
- Potable water should be used as a drilling fluid.
- In order to prevent possible damage to a core sample, a full core run should not be drilled if it suspected that part of a core from a previous run is still in the borehole. The next run shall be shortened by a factor equal to the length of any core still remaining downhole.

6.3.4 Rock Core Logging

A field log of each core must be completed and maintained by the project geologist. Table 6.11 lists and describes the information that is required for entry into each core log. The necessary information should be recorded on an appropriate rock core log form. An example of a rock core log form is illustrated in Table 6.10.

6.3.5 Rock Core Storage

Rock cores should be placed into wooden boxes constructed with partitions designed to hold core samples. The cores should be stored in stratigraphic order and labeled in such a way that indicates the stratigraphically up direction (PSE&G SOP 311,1997).

Wooden blocks should be placed in the storage boxes between each core run sample. The blocks shall be marked with the appropriate depths and run number. Each box should be labeled with the facility name and location, boring identification number, depth range, box number, and RQD.

6.3.6 Special Tests and Analyses of Rock Cores

The following analytical procedures can be applied to further examine rock core samples:

- Thin section analysis

Table 6.11 Rock Coring Requirements	
Information Required	**Notes**
Names of contractor, driller, and project geologist	
Core identification number and location	
Date and time of core commencement and completion	
Depth and size of casing	
Description of equipment used	
Type and condition of bit	
Depth of start and finish of each core run	
Core diameter	
Time required to drill each foot of core	
Total core recovery with information as to possible location of core losses	
Details of delays and breakdowns	
Macroscopic description of core	This description should include, but not be limited to, a photographic record of each core sample.
Depth to the water table and any other distinct water-bearing zones	
Characteristics of structures and fractures present	Fracture information should include the frequency, spacing, size, continuity and relative orientation of the fractures within the core sample. Any open fractures and joints should be noted.The description should note whether or not the fractures are due to natural or mechanical breaks.Calculating the Rock Quality Designation (RQD) can approximate the structural integrity of the rock. The RQD is equal to the total length of all core pieces exceeding four inches in length as a result of natural breaks (r) divided by the total length of the coring run (l). This result is converted to a percentage. RQD = (r/l)x100 The log shall include descriptions of the contacts between different rock units.
Description of lithology	The description of the rock should include information on rock type, color, composition, degree of stratification, hardness, fracturing, and degree of weathering. Any changes in lithology shall be noted.
Description of stratigraphy	Characteristics such as clarity and thickness of bedding should be described. The angle of bedding and other planar features in a non-oriented core should be measured from the perpendicular to the core axis (e.g., horizontal fracture in core equals 0°).
Description of any evidence of contamination present in core	Any evidence of contamination must be noted including elevated air monitoring instrument readings, odors, visual observations, and the presence of NAPL, etc.

- Observing stratigraphic direction or fossil indicators
- Chemical analysis
- Plotting fracture sets, joint sets and/or faults on stereographic projection or rose diagrams
- Radiometric age determinations
- Regional structural analysis
- Correlating facies changes
- Strain analysis

6.4 Direct Push Technology

Use of direct push technology to obtain soil samples in cored segments has gained wide acceptance. The relative ease to collect minimally disturbed soil samples at depth plus, the ability to visually determine geological data has made this system attractive. While various manufactures make and distribute their own soil sampling equipment and accessories, the same general principles still apply when collecting soil samples. Chief among them is following NJDEP required decontamination procedures. When using direct push technology you must apply, at a minimum, the Cold Regions decontamination procedure discussed in Chapter 2, *Quality Assurance*, Section 2.4., *Decontamination Procedures*.

One of the special applications of direct push technology relative to soil sampling is the ability to obtain vertical profile contaminant information while working the same bore hole. This process only further stresses the need to eliminate all possible sources of extraneous or cross contamination. High pressure, hot water (100° C) cleaning is the only acceptable means to decontaminate direct push sampling equipment and maintain confidence that data is not influenced by unwanted variables. In addition, equipment must be maintained in good working order to insure its performance. This means (but is not limited to) all rods used for boring advancement must have unworn O-rings (if applicable) at each connection and undamaged threads to insure that each connection can be drawn tight. All downhole equipment must be decontaminated between each use. Operators must have boring certification in good standing from the Bureau of Water Allocation and all permit approvals must be on-site. Extreme caution must be taken to insure that communication between various water bearing zones within the same boring does not take place therefore, all grouting must be tremied under pressure starting from the bottom of the boring and completed at the surface using grout of the required density. Finally, no boring work can begin without first contacting New Jersey One Call service to secure utility mark-outs.

Specific guidance on direct push technology for both soil and ground water sampling can be referenced through the USEPA document, *Expedited Site Assessment Tools for Underground Storage Tank Sites: A Guide for Regulators*, EPA 510-B-97-001. Released by the USEPA's Office of Underground Storage Tanks, this 60 page document contains "how to" discussion on soil and ground water sampling and the geotechnical tools and accessories available for direct push applications. The document can be viewed at: http://epa.gov/swerust1/pubs/esa-ch5.pdf.

Considerable general guidance on direct push technology can be referenced through the following USEPA website: http://www.epa.gov/superfund/programs/dfa/dirtech.htm. Additional information on direct push technology can be obtained through ASTM D6001-96, *Direct Push Water Sampling for Geoenvironmental Investigations*, and via the following vendor Internet links: http://geoprobe.com, and http://www.ams-samplers.com/main.shtm?PageName=welcome.shtm.